

EARLY DETECTION OF SENSORY MOTOR DEFICITS IN CHRONIC DIABETICS

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ABSTRACT

INTRODUCTION

Diabetes is a highly prevalent condition and is the leading cause of foot ulcerations and amputation (1). There are numerous complications associated with diabetes like impaired sensation at the extremities, reduced muscle strength, impaired proprioception and kinesthetic awareness, co-ordination and balance issues which might precede amputations. Hence the purpose of this study was early detection of any sensory-motor deficits through various assessments thus preventing future complications.

METHODOLOGY

Post institutional ethics committee approval, this retrospective cross sectional study was conducted on 60 consenting subjects with chronic diabetes.

DATA ANALYSIS & CONCLUSIONS

85 % of the study subjects reported a loss of protective sensations to completely absent sensations in the feet. 21% showed moderate to severe and 15 % severe impairment (NDS scale). 31% subjects had motor impairments reflected as a decline in static, dynamic balance and muscle strength in the lower extremities.

KEYWORDS: Diabetes Mellitus & Neuropathy

Original Article

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INTRODUCTION

Diabetes is a group of metabolic disorder with elevated blood glucose levels as a result of impaired glucagon and insulin levels (glucagon raises the blood sugar levels whereas insulin lowers it). The prevalence of diabetes today has reached epidemic proportions with an estimated 382 million people globally suffering from diabetes¹ which is estimated to double by 2030 (World Health Organization).

Diabetes is associated with serious health complications including cardiovascular and micro vascular complications. The other complications associated with diabetes are impaired sensation at the extremities, reduced muscle strength and flexibility, impaired proprioception and kinesthetic awareness, co-ordination and balance issues. Pain tolerance may also be affected due to the micro vascular complications. Patients also experience loss of co-ordination and balance due to affected proprioceptors and kinesthetic sensation. Early detection is the key to effective management to prevent further complications and hence, this study was undertaken to unravel the most sensitive sensory and motor tests that can be used for early detection of patients with type 2 diabetes mellitus at

risk of amputation.

The Aim of the Study

To detect early sensory-motor deficits like cutaneous sensations, pain threshold, temperature, vibration, proprioception, balance, muscle strength and Achilles tendon reflex in chronic diabetics.

METHODOLOGY

This retrospective cross-sectional assessment based study was conducted on 60 subjects diagnosed with diabetes for minimum 5 years who did not present with any sensory or motor symptoms. Written informed consent was taken from all the subjects before undertaking the assessment

Ethical Clearance

Ethical clearance was obtained by submitting a detailed methodology to the D. Y. Patil ethics committee. Written, informed consent was taken from the subjects and they were assured that the participation is anonymous.

A detailed questionnaire was drafted after due deliberation of the review of literature, it was then validated by an expert of the field. The following aspects were assessed.

For Sensory Evaluation

Semmes-Weinstein Monofilament- Monofilaments were applied to the test site perpendicularly for approximately one second until it slightly bends and the patient is instructed to say 'Yes' if he feels the sensation.. If the patient is unable to feel the sensations, a thicker diameter monofilament was used. Even after the filament with thickest diameter is used and the patient cannot feel the sensation then he is considered to have impaired sensations. 6.

For Sensory Threshold was tested with a diagnostic stimulator using galvanic current. It was tested at the tip of the toes. There are three components to this test.

- Sensory threshold (when the patient feels the current)
- Pain threshold (intensity is increased up to the point where the stimulus becomes nociceptive)
- Pain tolerance (the intensity at which the pain is unbearable by the patient).
- **Temperature Perception** – Two test tubes filled with warm and tap water respectively, were used to assess ability to discern temperature change.
- **Proprioception** – Subject asked to replicate movement 10 times. Failing for more than three times reflected affected proprioception⁷
- **Vibration** – A 128Hz tuning fork of was used to assess vibrations⁸.

Motor Assessment

Balance

Standing Stork was used for Static balance assessment. Four square step test and Tandem walking were used to measure Dynamic balance⁹.

Muscle Strength and Endurance – Was assessed with the sit-stand-sit test, wherein there are two components STS-1 and STS-60

STS-1- The patient was seated on a chair and was instructed to raise from the chair and stand and sit again. This activity was timed to 1 min and the patient was marked upon the number of seconds required to complete this task once. This test assesses the lower extremity muscle strength and force generating capacity.

STS-60:- The patient was instructed to repeat the task as many times as he can in one minute¹⁰

DATA ANALYSIS AND REPRESENTATION

Demographics

Gender Wise Distribution - 51% of the subjects were females and 48% were males

Age- Mean age of the subjects was 50 ± 7.68 years

Body Mass Index - 29% of the subjects were obese as per their BMI.

History of Medications intake- Medications- 48% of the subjects were on oral hypoglycemic

6.6% were on Insulin.

8.3% used a combination of oral hypoglycemic and insulin

Control on their sugar levels- 46% of the subjects had their sugar levels controlled and 55% had uncontrolled

Regular Check on Sugar Levels- 70% subjects regularly checked their sugar levels and 30% did not.

Exercise Level - 46% subjects performed regular exercise

40% did not exercise at all

Loss of Balance - 0.4% subject's loss, balance while walking

Footwear Sensation- 13% subjects observed their footwear coming off while walking

Patients presenting with Foot Ulcers – 6.6% subjects had a foot ulcer

Temperature Perception- 21% subjects had abnormal sensations

Tandem Walking- 23% subjects could not complete the activity

Rombergs - 8.3% subjects had a positive rombergs sign

Monofilament Sensation

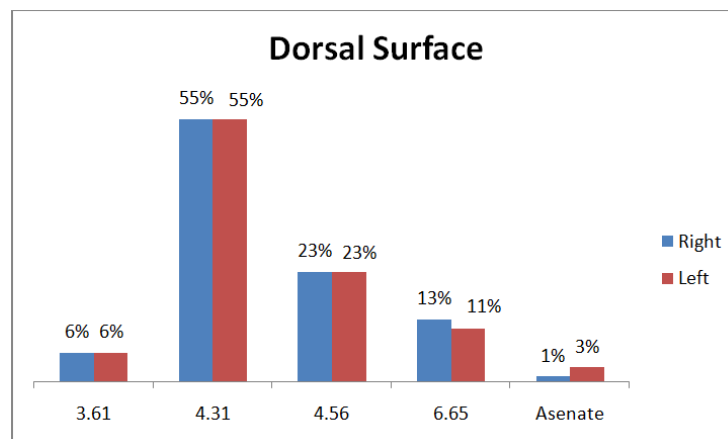


Figure 1: Dorsal Surface

Inference

6% of the subjects had diminished light touch on their right and left dorsal surface

55% had diminished protective sensation on their right and left dorsal surface

23% had a loss of protective sensation on their right and left dorsal surface

13% subjects reported deep pressure sensation only on the right dorsal surface

11% subjects reported deep pressure sensation only on the left dorsal surface

1 one the subjects could not feel any sensation with the monofilaments

3% reported absent sensation on the left dorsal surface

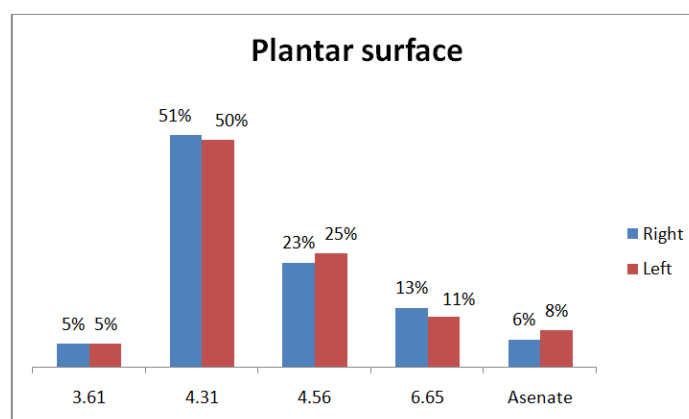


Figure 2: Plantar Surface

Inference

5% subjects reported diminished light touch on the right and left plantar surface

51% subjects reported diminished light touch on the right plantar surface and 50% reported the same on the left plantar surface.

23% subjects reported a loss of protective sensation on the right plantar surface and 25% reported the same on the left plantar surface

13% subjects reported deep pressure sensation only on the right plantar surface and 11% reported the same on the left plantar surface

6% subjects reported absent sensation on the right plantar surface and 8% on the left plantar surface.

Sensory & pain Threshold & tolerance in subjects with varying Sensory evaluation

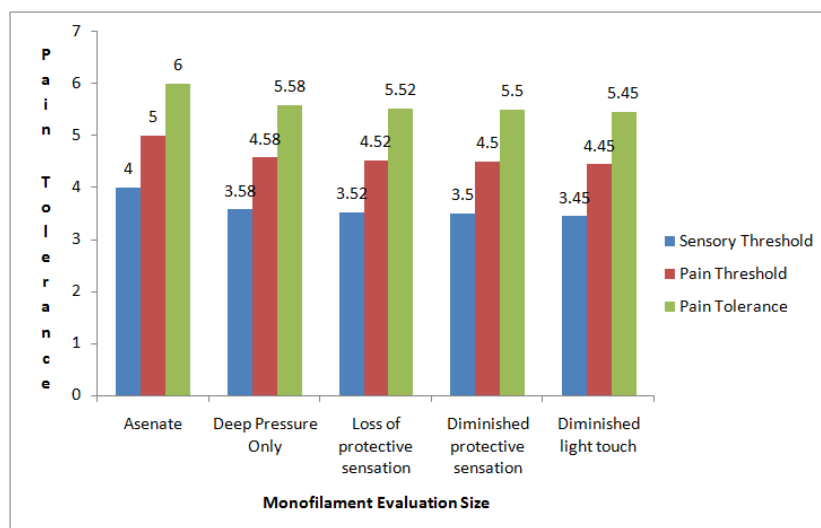


Figure 3: Monofilament Evaluation Size

DISCUSSIONS

Diabetes is a highly prevalent condition and is the leading cause of foot ulcerations and amputation. There are numerous complications associated with diabetes like impaired sensation at the extremities, reduced muscle strength, impaired proprioception and kinesthetic awareness, co-ordination and balance issues. The most common complication is impaired foot sensations which is also the leading cause of foot and lower extremity amputations. This purpose of this study is to detect any sensory-motor deficits at an early stage by carrying out an appropriate evaluation and prevent the preceding complications.

Age- The average age of the subjects diagnosed with diabetes was 50 years. The onset of symptoms of diabetes gradually occurs over and period of time and the patients visit the clinic only after the onset of symptoms, hence the age at which the patients are diagnosed with diabetes is in the later stages of life.

BMI- The average body mass index was 28 kg/m^2 . Most of the subjects belonged to obese category as per the BMI criteria for Asians cut off guidelines and obesity is the precursor of diabetes. Studies suggest that obesity alters the body's fat metabolism and causes the adipose tissues to release fat molecules which in turn affects the cells to respond to insulin and greatly affects insulin sensitivity. Obesity is considered as one of the most vital cause of developing diabetes and this fact correlated with the above data. A raise in bmi may be because of the physical inactivity or that a large population i. e 40% of the subjects did not exercise at all, while exercise has shown to be beneficial in improving glycemic control,, improving the insulin sensitivity thereby reducing the resistance along with diet¹¹

Monofilament Test - 61% subjects had diminished light touch and loss of protective sensation at the dorsal surface and 56% subjects had diminished light touch and loss of protection at the plantar surface of the foot. These subjects are at a greater risk of injuries at their extremity. Since their light touch perception is affected special foot care needs to be taken by regularly keeping a check on their feet for injuries, wearing appropriate footwear at home and outside. If blood glucose levels are high they would cause damage to the small diameter nerve fibers which are responsible for cutaneous sensations. These sensations include diminished light touch, protective sensations and deep pressure sensations. If these are affected the patients are at a greater risk of developing foot ulcers by sharp or blunt objects friction caused by the type of footwear used, loss of ability to detect changes in temperature, pain and loss of co-ordination and balance¹²

Sugar control levels - 55% had uncontrolled diabetes and there could be multiple reasons for this for e. g not taking medications regularly or continuing the same dosage for a very long period of time. Sometimes with the rise or fall of sugar levels, subjects need to be reassessed and treated accordingly, necessary measures need to be taken if neuropathy has already set in. Not paying regular visits to the physician, lack of knowledge concerning the serious complications of diabetes, diet, lack of physical activity all add up to the sugar levels remaining high^{13,14}

Subjects carrying out exercises - As per the above data, 40% subjects did not exercise at all, whereas exercise, diet, physical activity are the foundation to improve the insulin sensitivity, glycemic control, obesity, increase muscle strength and endurance, prevent motor related deficits etc. This states that despite clinical research focusing on exercise and its imperative control on blood glucose levels, there is less awareness amongst the general population and that it can have serious implications if proper avoided. GLUT 4 protein is a principal glucose transport protein which helps in mediating the glucose uptake and also regulated the body's glucose haemostasis. This glut4 protein helps in transporting the glucose across plasma membrane, thereby increasing the insulin uptake and sensitivity. The body's insulin sensitivity increases post exercise and can persist upto 24-48 hrs. A study carried out on insulin stimulated glucose uptake in normal and insulin resisted skeletal muscle proves that glucose uptake increased post exercise¹⁴. Another study also proves that high intensity exercise greatly improves insulin sensitivity as compared to a moderate intensity exercise¹⁴.

Loss of Balance - The ability to stand erect requires a sequence of events such as the sensory (visual, vestibular and proprioception) and motor (mechanoreceptors) and muscular contraction. All of the above functions are impaired with high glucagon levels and affects the small diameter nerve fibers 0.4% subjects reported loss of balance while walking which could be because of the diabetic sensory neuropathy that must have set in which affects the mechanoreceptors and proprioceptors in carrying out the necessary activity. With neuropathy there is a decline in the sensory function and execution which causes the loss of balance and increases the risk of falls and measures must be taken to prevent this. (rol ref)

Subjects having foot ulcers - 7% patients had foot ulcers at the time of assessment and this correlates to the finding that light touch sensation is affected which is one of the major causes of foot ulcers. A study also reveals that the pain threshold is higher in diabetic patients which could also be the cause of developing foot ulcers as the patient may not have realized that he has hurt himself while carrying out his day to day activities. A study also suggests that the healing time is accelerated in diabetic patients, which further adds up to the healing process.

Measuring pain threshold and tolerance- In the above data, as the size of the monofilament decreased the mean of pain threshold also decreased. This shows that there is a liner relation with respect to monofilament sensation and pain threshold. With a smaller diameter monofilament, the sensory thresholds were lower and with larger diameter

monofilament the pain threshold were higher which means that the sensations were affected in these patients even though they were asymptomatic with a longer period of acquiring diabetes.

Tandem Walking- According to this study, 23% subjects reported that they could not complete the activity during the assessment. This states that these percentage of the subjects may have developed neuropathy. Tandem walking for the lower extremity was assessed to know if there is activation and execution of multiple muscles which may have been affected due to the neuropathy.

Temperature Perception – According to the above data, 21% had impaired foot sensations. Thermoregulation is affected in patients with diabetic neuropathy. Sudomotor and micro vascular involvement have been suggested to be one of the reasons for impaired foot sensations. These subjects are more prone to develop further complications as the micro vascular neuropathy leads to damage of blood vessels and small nerve fibers which affects the normal heat or cold perception. Because of the inability to perceive temperature sensations, patients are unable to differentiate any temperature related differences and hence are at a greater risk of developing heat burns, electrical burns or frostbite. Hence, diabetic's foot care is an important aspect for preventing such injuries.

Proprioception Perception - Proprioceptions play a major role in stabilizing the body's equilibrium and is most commonly affected in diabetic sensory neuropathy due to the degeneration of the small nerve fibers. It is the proprioceptors who are responsible to respond to the stresses placed on the body by alteration of movement or posture. Degeneration of the nerve fibers affects ones stability and balance which correlates with the above data stating 0.4% of the study subjects majorly lost balance while walking and 6% lost balance sometimes. The study also states that 13% subjects reported that their footwear came off while walking and they did not perceive this change while walking¹⁵

Table 1: Muscle Strength

Test	Data Value	Normative Value
Four Square Step Test	5.95 seconds	7.49seconds
Sit to Stand for 1 min	20 repetitions	40 repetitions

Sarcopenia is a common factor as a part of ageing where there is loss of muscle function and development of muscle atrophy. Studies suggest that increased glucose levels accelerate muscle atrophy and strength. Muscle atrophy is caused by an imbalance in the protein synthesis and degradation of which diabetes in a triggering factor and can lead to reduced physical activity and accelerate further impairments. It is also the cause of muscle weakness in the lower extremities. According to the data, the average number of repetitions the subjects could carry out in one minute as per the sit to stand test was 20 ± 4 SD. The normal values are 40 repetitions for the age group 50-55 years in healthy adults. The results of the above data confirm that the muscle strength is affected among diabetic patients as a result of motor neuropathy as stated by other studies¹⁴

Table 2: Neuropathy Disability score

Test	Range of Impairment	Severity	Data Value
Neuropathy Disability Score	Score <2	No neuropathy	61%
	Score 3-5	Mild neuropathy	18%
	Score 6-8	Moderate neuropathy	20%
	Score 9, 10	Severe Neuropathy	1%

This scale was used to assess vibration, temperature, pin prick and Achilles tendon reflex. The table below represents the analysis of the patients with their respective neuropathy disability score. 18% subjects show mild

impairment of the above sensations with a NDS score ranging between 3 and 5.

20% subjects show moderate impairment with a score ranging from 6 to 8. These patients are subject to complications sooner or later because of the deficits they are unaware of. Subjects with moderate to severe NDS score must undergo a nerve conduction study for further results since NCS is a more sensitive test for identifying the severity with its parameters such as conduction velocity, latency, amplitude etc. These patients are chronic diabetics and asymptomatic and early detection is the key to halt the progression of the condition at this stage¹⁵

CONCLUSIONS

- 85 % of the study subjects reported a loss of protective sensations to completely absent sensations in the feet (dorsal and plantar surface) with the Semmes Weinstein monofilament test. These subjects had sensory affection who were asymptomatic and were diagnosed with sensory deficits at a sub clinical level
- 21% reported moderate to severe impairment and 15% severe impairment with the NDS scale.
- 31% subjects revealed motor impairments comprising of static, dynamic balance and muscle strength in the lower extremities.

Conflict of Interest

There exists no conflict of interest to the best of my knowledge.

ACKNOWLEDGEMENT

This study was carried out in the Diabetic OPD at D. Y. Patil Health and Research Center.

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